ZOOLOGY.—*A redescription of two parasitic copepods from Bermuda.*[1] HARRY C. YEATMAN, University of the South. (Communicated by Fenner A. Chace, Jr.)

(Received June 20, 1957)

When investigating the littoral and neritic copepods of Bermuda during July and August 1955, I became interested in the apparent scarcity of parasitic copepods on fishes observed. A preliminary collection of 2 squirrelfishes, *Holocentrus ascensionis* (Osbeck); 1 hamlet, *Epinephelus striatus* (Bloch); 4 gray snappers, *Lutianus griseus* (Linnaeus); 7 breams, *Diplodus argenteus* (Cuvier and Valenciennes); and 1 chub, *Kyphosus sectatrix* (Linnaeus) was examined for parasitic Crustacea. The last three species carried an abundance of parasitic isopods, *Exocirolana mayana* (Ives), but none was infested with copepods. These isopods have been sent to the U. S. National Museum (99587). Wilson (1913) found that isopods were quite abundant and that parasitic copepods were few on the fish he examined at Jamaica, B.W.I.

On August 17, 1955, David Menzel, a graduate student at the University of Michigan, collected 2 female copepods from a tiger rockfish or gag, *Mycteroperca tigris* (Cuvier and Valenciennes), taken off North Rock, Bermuda. These were given to me and proved to be perfect specimens of *Dentigryps curtus* Wilson. These differed from Wilson's (1913) original description chiefly in the armature of the feet and caudal rami. Through the kindness of the Division of Marine Invertebrates of the U. S. National Museum, I was able to examine the type specimen and two paratype specimens, and these showed by the presence of attachment bases that some prominent setae had been broken off.

It is very desirable to redescribe a species if the original specimens were incomplete in structure, and even more desirable if there is danger that someone will describe a complete specimen of this species as a new species. This has been done many times in the past. Taxonomic literature is already overcrowded with synonyms.

Specimens of *Lepeophtheirus dissimulatus* Wilson were also lent by the U. S. National Museum. This species is redescribed here because of its rather close resemblance to the complete specimens of *Dentigryps curtus*. I was unable to obtain specimens at Bermuda.

Wilson (1936) found a single specimen of *Caligus curtus* Muller in a deep-water plankton haul made by Dr. William Beebe at Bermuda. There is no other Bermuda record of this species, but it may occur there on deep-water fishes even though its common hosts, cod, hake, haddock, pollack, halibut, and barn-door skate, have not been reported from Bermuda.

These three species are the only ones reported from Bermuda. I did see a copepod taken from a shark, but unfortunately it was not obtained for examination.

The author wishes to express thanks to David Menzel for the specimens of *Dentigryps curtus*, to Dr. Fenner A. Chace, Jr., and Dr. Thomas E. Bowman of the U. S. National Museum for the loan of type specimens and literature, to Dr. William H. Sutcliffe, Jr., director of the Bermuda Biological Station, for the privileges of the laboratory and many courtesies. He also wishes to thank the National Science Foundation and the University of the South Research Fund Committee for financial aid in the study of certain groups of copepods of which this investigation is only a small part.

Dentigryps curtus C. B. Wilson (1913), new description

Figs. 1–16

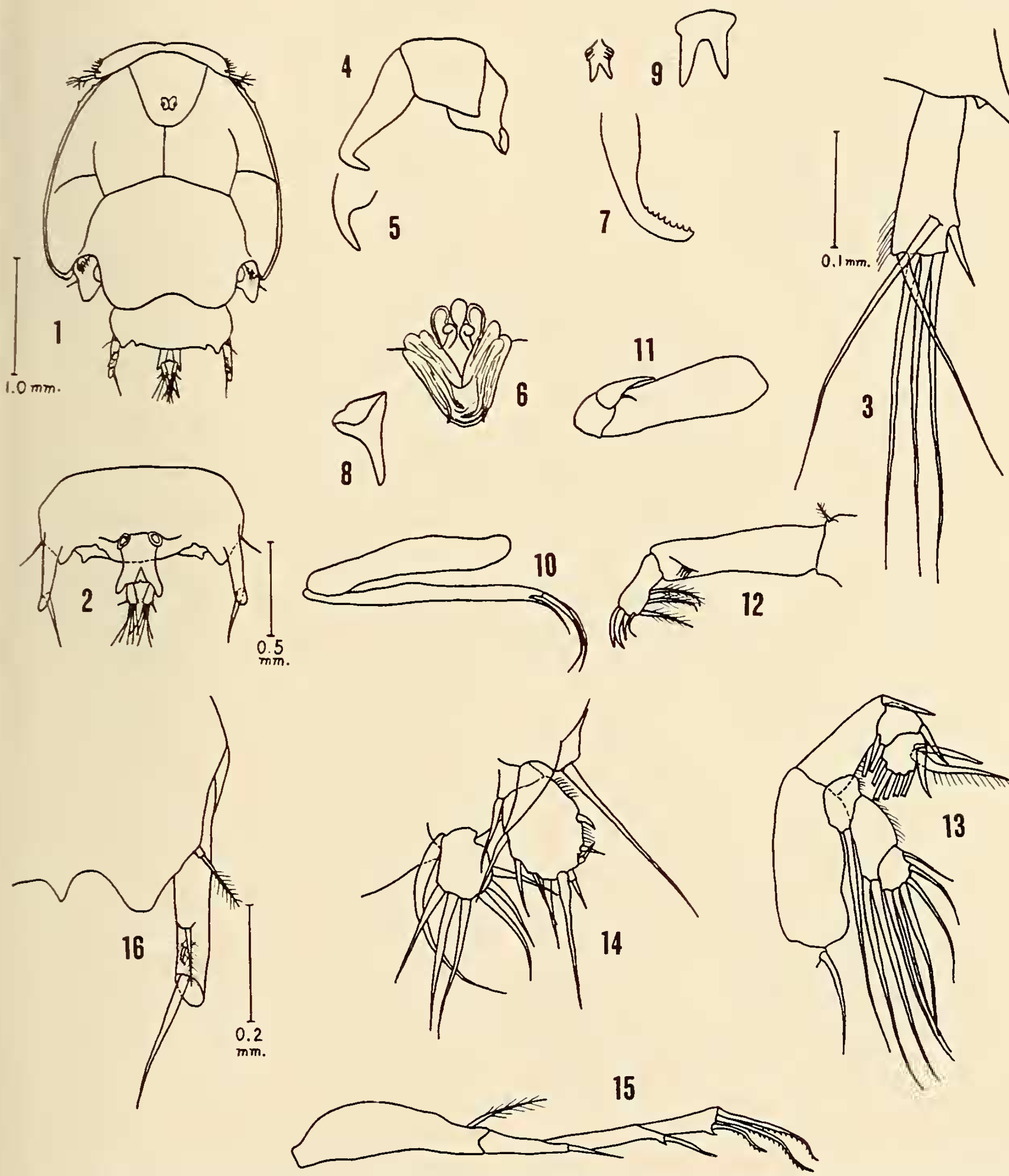
Specimens examined.—One mature female (type specimen, U.S.N.M. 43595) collected from mouth of yellow-finned grouper, *Mycteroperca venenosa apua* (Bloch) by Dr. Edwin Linton, Bermuda Islands, July 27, 1903.

Two mature females (paratypes, U.S.N.M. 42328) collected from *Mycteroperca v. apua* by Louis L. Mowbray, Bermuda Islands, July 27, 1903.

[1] Contribution no. 232 from the Bermuda Biological Station.

Two mature females (U.S.N.M. 100899) collected from tiger rockfish or gag, *Mycteroperca tigris* (Cuvier and Valenciennes), taken off North Rock, Bermuda, at a depth of 30 fathoms by David Menzel, August 17, 1955. Identified by H. C. Yeatman.

Description of female.—Length 2.85 to 3.60 mm, not including terminal setae of caudal rami. General body form elliptical. The widely truncated posterior margin of the genital segment gives the appearance that some of the posterior body is missing. Carapace is about as wide as long and much longer than the remainder of the body. Grooving of the carapace as in Fig.



Figs. 1–16.—*Dentigryps curtus* C. B. Wilson: 1, Female, dorsal view; 2, genital segment and abdomen, ventral view; 3, right caudal ramus, dorsal view; 4, second antenna; 5, lateral hook; 6, mouth tube; 7, mandible; 8, right first maxilla; 9, furca from two different specimens; 10, second maxilla; 11, maxilliped; 12, first leg; 13, second leg; 14, third leg; 15, fourth leg; 16, fifth leg, dorsal view. (Figs. 3, 13, and 14 drawn to same scale. Figures 4–6, 8–12, 15, and 16 drawn to same scale.)

1. Frontal plates are without lunules and are well developed. Eyes fairly small and anteriorly placed. In none of the specimens I have examined are the eyes as large and round as Wilson (1913) shows in his figure 127.

Fourth and fifth body segments fused with the genital segment and all three covered by a single dorsal plate, which is as wide as the thoracic portion of the carapace. This character enables this species to be distinguished from *Lepeophtheirus dissimulatus* at a glance (see below). Posterior border of genital segment is widely truncated and bears at its posteriolateral corners a small inner knob, a larger middle knob, and a very large outer conical prong. These prongs are somewhat more ventral than are the knobs. They represent the fifth legs and their armature is described below.

The single abdominal segment is attached to the posteroventral surface of the genital segment (Fig. 2) and is about 1½ times as long as wide. Its posterolateral corners protrude posteriorly. Caudal rami are about three times as long as the width at the middle. The distal end is noticeably wider than the base. The inner distal margins are hairy. Wilson (1913) described and drew three terminal setae on each ramus, but the type and paratype specimens show by attachment bases that 3 more appendages belong on each. My undamaged specimens show one outer subterminal spine, one subterminal dorsal seta and four terminal setae on each ramus (Fig. 3).

Egg strings resemble those of *Lepeophtheirus dissimulatus* (see below).

First antennae short and armed as in Fig. 1. Second antennae stout and composed of two well-defined segments. The terminal end bent abruptly near its end to form a claw.

A lateral prehensile hook is present posterior to each second antenna. This hook is slightly curved medially and lacks any appendages. This hook, found in the Caligidae, was earlier wrongly described by Wilson (1905) as the first maxilla. He corrected the error before he described this species, but some fairly recent descriptions of specimens of Caligidae have copied his early mistakes.

Mouth tube is short and blunt and its details of structure are difficult to see without dissection mandible with about eight or nine teeth.

First maxillae are undivided, almost straight prongs and are posterolateral to the mouth tube.

Second maxillae are 2-jointed; the second joint longer and more slender than the first and armed distally with two terminal setae and one subterminal spine. These setae, unlike the spine, are separated from the segment by a distinct joint.

Maxillipeds are stout. The terminal claw bears a small spine on its inner margin.

The furca consists of two smooth prongs and a base that may or may not be marked with circular striations. The caudal rami of free-living copepods are sometimes called furcal rami. The furca of parasitic copepods is not to be confused with the caudal rami.

First legs consist of a basal segment bearing a short spine and a two-segmented exopod. The proximal segment bears a short comb of small setae near its distal end. The second segment is armed with three spines and one seta at its distal end and three lateral setae.

Second legs with 3-segmented exopod and endopod and armed as in Fig. 13.

Third legs as in Fig. 14. Terminal segment of exopod is armed with nine appendages (spines and setae), not six as in Wilson's (1913) figure 133. Terminal segment of endopod is armed with six appendages, not four.

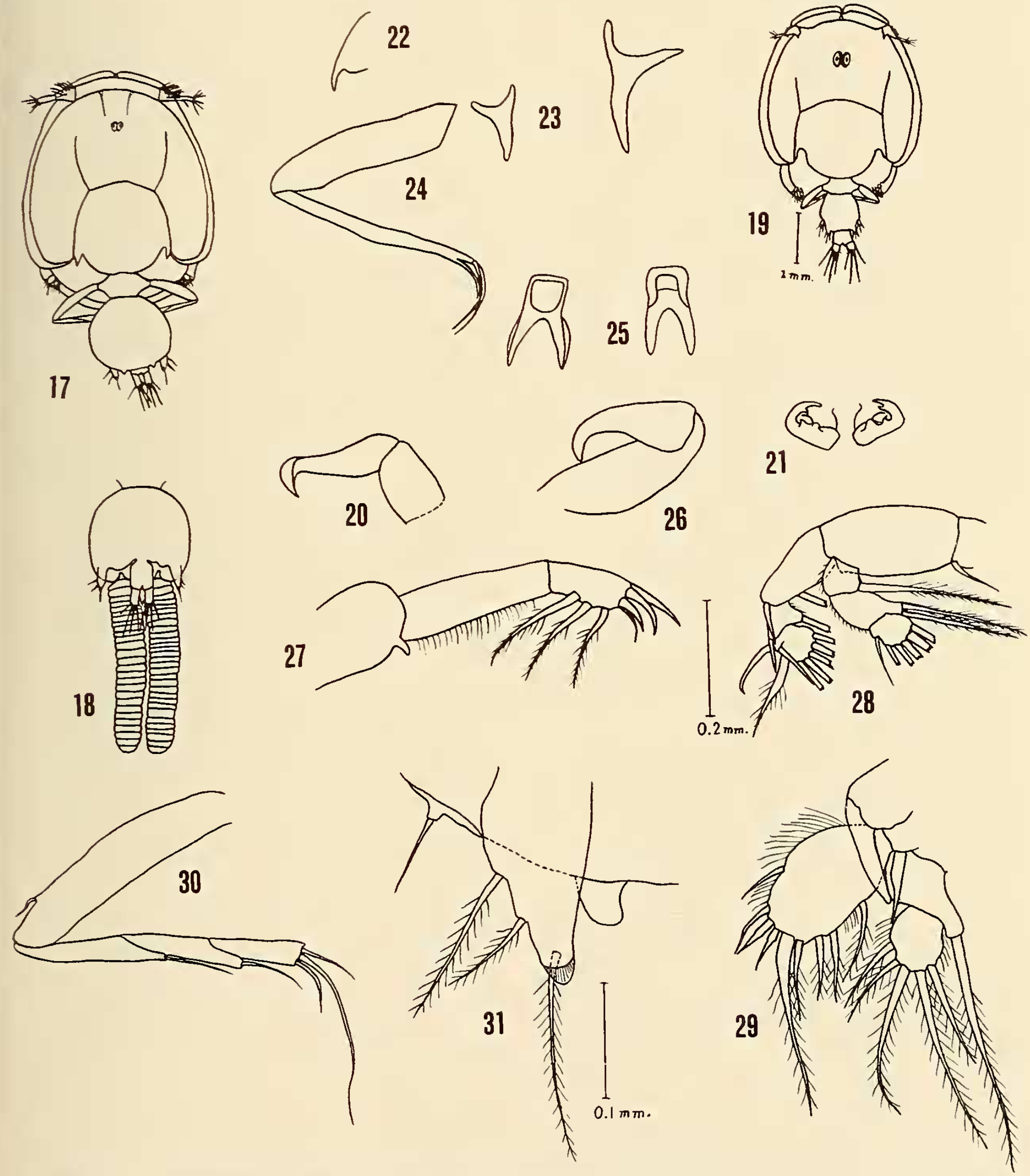
Fourth legs consist of only one slender ramus. Basal segment bears a seta or spine near the distal end. Second and third segments bear a terminal spine each, and fourth segment with three distal spines.

The fifth legs were described by Wilson (1913) as being "perfectly smooth" and "cut off obliquely at the tips." In one of his females he found "a single, long, non-plumose spine near the tip of each prong." His drawings show no appendages attached to this prong. A quick glance at the fifth legs of my undamaged specimens would make an examiner think that here was a new species within the genus *Dentigryps*. Wilson, however, overlooked some of the small setae that are actually present in his type specimen. The other missing appendages (spines and setae) indicate their former presence by their attachment bases. A dorsal view of an undamaged fifth leg shows a short dorsolateral seta on a small papilla near the base of the long, distinct segment. The long segment bears one short, straight seta attached just beyond the middle and a shorter curved seta between it and the oblique end. A long smooth spine is attached to the proximal portion of the slanting end of the segment (Fig. 16).

The male as yet remains unknown. More extensive collecting and examination of the groupers around Bermuda will undoubtedly obtain this missing sex.

Distribution.—Bermuda Islands on yellow-finned grouper, *Mycteroperca venenosa apua* (Bloch) and tiger rockfish or gag, *Mycteroperca tigris* (Cuvier and Valenciennes).

Dry Tortugas, Fla., on yellow-finned grouper, *M. v. apua.*



Figs. 17–31.—*Lepeophtheirus dissimulatus* C. B. Wilson: 17, Female, dorsal view; 18, genital segment, egg sacs, and abdomen, ventral view; 19, male, dorsal view (after Wilson, 1905); 20, second antenna of female; 21, second antenna of male (after Wilson, 1905); 22, lateral hook; 23, first maxillae from two different specimens; 24, second maxilla; 25, furca from two different specimens; 26, maxilliped; 27, first leg; 28, second leg; 29, third leg; 30, fourth leg; 31, fifth leg, ventral view. (Figs. 20, 22–28, and 30 drawn to same scale. Figs. 29 and 31 drawn to same scale.)

Lepeophtheirus dissimulatus C. B. Wilson (1905), new description

Figs. 17–31

Specimens examined.—Three mature females, U.S.N.M. 42073. Collected by E. Linton July 11, 1903, from red grouper, *Epinephelus morio* (Cuvier and Valenciennes), Bermuda Islands. Identified by C. B. Wilson.

One mature female, U.S.N.M. 42276. From gills of yellow-finned grouper, *Mycteroperca venenosa apua* (Bloch), Bermuda Islands, September 27, 1903. Identified by C. B. Wilson.

Description of female.—Length 2.40 to 3.54 mm, not including terminal setae of caudal rami. Carapace as wide as long or slightly longer and much longer than the remainder of the body. Grooving of carapace as in Fig. 17. Frontal plates well developed and without lunules. Eyes small and anteriorly placed. Free thoracic segment short and more than a third as wide as genital segment.

Genital segment more or less spherical. Its posterior margin bears two small medial projections and 2 conspicuous lateral projections which represent the fifth legs (see below).

The single abdominal segment small and attached to the posteroventral surface of the genital segment. Caudal rami about twice as long as wide and armed with 4 fairly long terminal setae. It is possible that a fifth seta is present and has been broken off. If so, its attachment base is very difficult to see. The posterior inner margins of these caudal rami are hairy.

Egg strings are long and wide and are attached at points dorsolateral to the abdomen; 15 to 30 eggs are present in each string.

First antennae of two segments and armed as in Fig. 17.

Second antennae of two segments with a strongly curved terminal hook. These segments bear neither spines nor setae.

Lateral prehensile hooks, which were wrongly called first maxillae by Wilson (1905), are small and not armed with setae.

First maxillae are conspicuous, slightly inwardly curved spines.

Second maxillae are elongate and consist of two segments. The basal segment is wider but shorter than the terminal segment. The distal end of the second segment is armed with two long terminal setae which are jointed at their bases and a shorter curved subterminal spine which is not separated from its segment by a joint.

Furca with branches slightly laterally inclined. Branches are slightly more than half the furcal length and may or may not bear a slight wing or thin ridge on their outer margins.

Maxillipeds consist of two segments, the distal, hooklike segment is shorter than the proximal and not armed with setae or spines.

First legs consist of a basal segment bearing a short unjointed spine and a 2-segmented exopod. The terminal segment bears three spines and one seta at its distal end and three lateral setae.

Second legs with 3-segmented exopod and endopod and armed as in Fig. 28.

Third legs as in Fig. 29. Terminal segment of exopod is usually armed with nine appendages (setae and/or spines) instead of the five that Wilson (1905) shows in his figure 271. Terminal segment of endopod is armed with five appendages as Wilson shows.

Fourth legs consist of only one ramus. Basal segment with a small spine or seta on outer margin near distal end. Second and third segments with a terminal spine each, and fourth segment with three distal appendages.

Fifth legs, mentioned above, are not separated from the genital segment by a joint. There is a lateral seta on a tiny papilla and a subterminal seta and two lateral setae on a much larger papilla.

Description of male.—Length about 2.5 mm. Similar to female, but with free thoracic segment about as wide as genital segment which is squarely truncated posteriorly.

Second antennae longer than in female and branched (Fig. 21).

Fifth legs as in female, but more anteriorly placed and apparently lacking the outer seta.

Sixth legs consist of a pair of papillae, one at posterolateral margin of genital segment on each side. This papilla is armed with three spines.

Distribution.—Charles Island, Galapagos Islands, on white-spotted serranus, *Epinephelus labriformis*.

Bermuda Islands on Nassau grouper, *Epinephelus striatus* (Bloch); red grouper, *Epinephelus morio* (Cuvier and Valenciennes); yellow-finned grouper, *Mycteroperca venenosa apua* (Bloch).

Dry Tortugas, Fla., on the smooth trunkfish, *Lactophrys triqueter* (Linnaeus).

DISCUSSION OF SCARCITY OF COPEPOD PARASITES ON BERMUDA FISHES

Only the two above redescribed species of copepods have been reported from Bermuda fishes, and, as mentioned above, another species, *Caligus curtus*, was collected in a plankton net. Without checking collecting data and the environmental condititions, one is tempted to ask whether they are really scarce and, if so, why are they scarce? Perhaps the proper species of fishes have not been examined or are not present at Bermuda. Some species are commonly infested with copepods and others rarely, if ever, carry copepods. Sharks and rays nearly always carry parasitic copepods. The former are not particularly common at Bermuda, and only occasional specimens of rays consisting of two species have been reported. Next, one asks whether there are common species of fishes at Bermuda that are reported to be hosts of copepods at other localities.

Perhaps insufficient numbers of fishes have been examined. A. S. Pearse (1951) examined 368 fishes of 73 species at Bimini, Bahamas. Of these, 171 individuals of 23 species carried 290 copepods, but 140 fishes of 50 species carried none.

Perhaps the Bermuda fishes are examined too late after capture and by inexperienced copepod collectors. A good many parasitic copepods, especially those of the families Caligidae and Argulidae, will crawl off a dying fish and escape into the surrounding water or into the bottom of a boat or fishbox. Of course, a collector should be able to recognize parasitic copepods and look for them in the proper parts of the fish.

Edwin Linton (1905) spent July and August of 1901 and 1902 at Beaufort, N. C., examining 2,051 fishes of 59 species for all types of parasites. Of these, 17 species of 16 genera were carrying parasitic copepods. Some of these fishes were heavily infested with copepods.

In July and August 1903, Linton (1907) examined 263 fishes of 53 species at Bermuda. Of these, 130 fishes of 20 species have been proved to be hosts of parasitic copepods at Beaufort, N. C.; the Dry Tortugas, Fla.; Bimini, Bahama Islands; and Montego Bay, Jamaica (see bibliography). Two of these fishes carried two copepods each—a total of 4 copepods from 263 fishes examined by a man experienced in finding copepods and other parasites.

Most copepods which are parasitic on fishes do not confine their preference to a particular species but may be found on any species within a genus, or on any species within a family, or even on rather unrelated species of fish. Collecting records are full of evidence to substantiate this. If genera instead of species of fishes are counted, Linton's Bermuda catch included 193 fishes of 24 genera which contain proved hosts of copepods.

Many authors simply list the fish hosts which harbor copepod parasites and omit those which are free of such. Nevertheless, these lists furnish useful information for comparison purposes.

C. B. Wilson (1913) at Jamaica listed 26 species of fishes from which he obtained copepods in 1910. Of these, 19 are found at Bermuda and many are common. Of the 7 species not found at Bermuda, 6 of their genera are represented.

Wilson (1935) examined collections of parasitic copepods secured from Dr. H. W. Manter and Dr. O. L. Williams at the Dry Tortugas, Fla. Of the 30 species of fishes found infected with parasitic copepods, 19 are reported from Bermuda and 6 of these are of rare occurrence. Eleven are not present in Bermuda, but the genera of four of these are represented. In other words, 13 of these species are common in Bermuda and should yield copepods.

A. S. Pearse (1951) listed 23 species of copepods infesting fishes at Bimini Bahamas. Of these, 17 species are found at Bermuda plus two genera represented by different species.

The above information indicates that the proper copepod hosts are present at Bermuda, but that examination of more specimens is very desirable. Emphasis should be on examination of the jolthead porgy, *Calamus bajanado* (Bloch and Schneider); the great barracuda, *Sphyraena barracuda*

(Shaw); and species of sharks, snappers, groupers, puffers, and mullets which usually carry many copepods.

The possibility of undesirable environmental conditions should be considered if future extensive collecting proves that parasitic copepods are as scarce as they now appear to be.

Wilson (1905) stated that copepods of the family Caligidae are quickly killed by a rise of a few degrees in temperature and that A. Scott gives 16° C. as the upper limit for *Lepeophtheirus pectoralis*. Experiment has shown that other species do not differ much from this, some having upper tolerance limits of 18° or 20° C. This susceptibility to warm water may limit the distribution of these copepods to cool waters either at considerable depths or at higher latitudes. Most of the shallow water at Bermuda is considerably above 20° C., and it is notable that most of the copepod-infested groupers at Bermuda were caught in fairly deep water. My two specimens of *Dentigryps curtus* were collected by D. Menzel from a gag taken at a depth of 30 fathoms.

One theory concerning the scarcity of parasitic copepods on Bermuda fishes holds that many of the planktonic nauplius stages are carried away from Bermuda by the currents before they can reach the stage which attaches to host fish.

As mentioned above, the isopod *Excirolana mayana* (Ives) commonly infests groupers, snappers, breams, and chubs at Bermuda. Why are these common and parasitic copepods rare on Bermuda fishes? The answer may be concerned with the differences in life histories of the two groups, or with differences in physiological requirements, or with both. The larval stages (nauplii) of parasitic copepods may be more planktonic than the larval stages of this species of isopod. If so, there is more chance that the former will be carried away by ocean currents.

As mentioned above, many species of parasitic copepods cannot tolerate high temperatures, and thus their distribution may be limited to the cool water outside the encircling reefs. Consequently they may be subjected to more currents which tend to sweep the larvae away.

Boden (1952) found that salinities and temperatures in the Bermuda "lagoon" were consistently higher than in outside waters in the summer. He shows that the currents within this lagoon become cooled by contact with the cold ocean water at the platform margins and thus sink and return to the lagoon instead of flowing out to be carried away, mixed with oceanic currents. This effectively conserves much of the insular plankton in the summer when reproductive activities of most marine organisms are at their maximum.

Plankton volumes were consistently higher within the lagoon than at the outer stations.

If some parasitic copepod species are confined to the outer cool water by temperature barriers, their chances of becoming numerous are much less than if they were able to live and reproduce within the lagoon.

My specimens of isopods were collected in relatively warm bays which are fairly calm even during storms. Whether or not these isopods can tolerate cold or deep water conditions has not been determined.

Finally, the possibility of excessive predation on parasitic copepods must be considered. Beebe and other observers, including myself, have observed the butterflyfish, *Chaeton capistratus* Linnaeus, eating crustacean parasites from the sides and from inside the mouths of gray snappers, *Lutianus griseus* (Linnaeus). These butterflyfishes are common about the harbors and inner reefs of Bermuda. There is some evidence that parasitic isopods which commonly infest Bermuda fish may eat copepod parasites of fishes. Some are very voracious and will even bite a collector's hand.

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ENTOMOLOGY IN WORLD WAR II

Since the start of World War II man has gone far toward the conquest of an enemy in some ways more vicious than any human foe—the insect. More than a million-and-a-half American soldiers were put out of action—many permanently—by insect-transmitted diseases during the progress of hostilities. Deaths in some areas exceeded those from wounds and accidents.

The story of the remarkable progress during the war, when balance of battle several times depended on beating the disease-carrying insects as well as Japanese or Germans, is told by Col. Emory C. Cushing, U. S. A., Ret., in a publication prepared under the general direction of a committee of the Entomological Society of America and the American Association of Economic Entomologists and recently issued by the Smithsonian Institution. Some of the victories, Colonel Cushing points out, probably represent permanent gains. Others may be temporary as insects adjust to the new weapons forged under the stress of emergency. Unfortunately, most of the gains came too late during the war itself to prevent an enormous amount of suffering and disablement.

Greatest offender of the insect-transmitted maladies was dysentery. This appears to have been the case in most major wars since those of Greeks and Egyptians before the Christian era. Easily second was the even more disabling malaria. The enemy, of course, suffered just as much. Malaria outbreaks were the major reason for German abandonment of both Corsica and Sardinia with hardly a shot fired, Colonel Cushing points out.

Much of the fight was carried on by entomologists at the Orlando, Fla., and Beltsville, Md., stations of the Department of Agriculture's Bureau of Entomology and Plant Quarantine. Effective insect repellents and killers were developed, but, since the problem had received little attention until the actual outbreak of war, some of these came too late to help. One difficulty was that new kinds of insect disease carriers, with which the researchers had no previous experience, constantly were appearing. It was only near the end of hostilities that the general fly, louse, and mosquito insecticide, DDT, could be supplied to troops in sufficient quantities.

That needs often were urgent is illustrated by Colonel Cushing with accounts of some little-known war incidents. For example, he quotes from a report:

> The men at the front in New Guinea were perhaps the most wretched looking soldiers ever to wear the American uniform. They were gaunt and thin, with deep black circles under their sunken eyes.... Many of them fought for days with fevers and didn't know it.... Malaria, dengue fever, and dysentery, and in a few cases typhus, hit man after man. There was hardly a soldier amongst the thousands who went into the jungle who did not come down with some kind of fever at least once.

Sand flies, with which American entomologists generally were unfamiliar before the war, might have cost victory in Sicily. "In the battle for Sicily," Colonel Cushing recounts, "31,158 soldiers were killed; *Phlebotomus* [the sand fly] put several thousand more out of action at a time when all available manpower was sorely needed for the invasion of Italy. From the Sicilian hills the sand flies welcomed the newcomers by pumping dose after dose of papataci fever into their nonresistant bodies. Within a short week after the initial landing hundreds of men with the new and unfamiliar disease filled the hospitals. Unrecognized by the Army medical officers, many of these cases were considered to be simply relapses of malaria contracted in North Africa and entered on the hospital records as 'f.u.o.' (fever of unknown origin)."